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MASSACHUSETTS PESTICIDE MONITORING STUDY

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Massachusetts Health Research Institute, Incorporated
Westboro, Massachusetts

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MASSACHUSETTS PESTICIDE MONITORING STUDY

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I

ABSTRACT

Indigenous fresh water fish species were collected in all of the major watersheds in Massachusetts during the summers of 1965, 1966, and 1967 and an individual analysis of these fish conducted to determine the concentrations of DDT and metabolites, DDE and DDD (TDE). In all, 1,310 individual fish specimens were collected and analyzed from 93 stations. Mean DDT concentrations based on the analysis of five fish per station ranged from 0.17 to 28.88 parts per million. The DDT range for individual fish specimens was 0.00 to 49.10 parts per million. A study of factors relating to the concentration of pesticide by fish showed that some fish species had varying abilities to concentrate DDT.

Neither length nor weight was related to the concentration of pesticide found in yellow perch and pumpkinseed. Some samples portrayed extreme variation in the concentration of pesticide found in individual fish comprising the sample. These variations could not be explained.

Results of this study are expressed in parts per million of pesticide found in whole fish and based on dry weight. Conversion factors to convert parts per million based on dry weight to parts per million based on wet weight were determined for nine species of fish.

INTRODUCTION

In 1965 the Massachusetts Health Research Institute, Inc., in cooperation with the Massachusetts Division of Fisheries and Game initiated a limited statewide pesticide monitoring program.

The three-year study was carried out with a demonstration grant WPD 88-02 from the United States Department of the Interior, Federal Water Pollution Control Administration. The primary objective of this project was to monitor the major watersheds of the Commonwealth of Massachusetts for DDT and metabolites using fish from the various watersheds as indicator organisms. In 1964 Burdick et al (1) used fish to demonstrate the presence of a pesticide in an aquatic environment. Reed (2), and Anderson et al (3) also did similar studies relating to DDT and fish. Weiss (4) and Johnson et al (5) discussed the use of fish as indicator organisms.

The levels of pesticide expressed in this study cannot be interpreted as quantitative values representing the amounts of DDT in either the aquatic environment or the individual watersheds. However, the annual analysis of fish from specific locations over a period of years, can indicate trends in the use of DDT in each particular watershed. Over a three-year period, 1965-1967, a number of sampling stations were established in the major watersheds located throughout the state. Fish samples were collected at these stations from June through October and analyzed for DDT and metabolites. A statistical evaluation of the data was perfomred to determine the relative concentrations of pesticides within each of the sampling stations. Other studies were conducted in an endeavor to determine if there was a relationship between the pesticide concentration and the fish species. Such characteristics as length and weight of the fish were also evaluated in relationship to their influence on the concentration of DDT within and between species.

SAMPLING

In 1965 sampling sites were selected from various parts of the state including as many watersheds as possible. The samples collected from each station consisted of many fish species and age classes of various lengths and weights. At the conclusion of the first year's sampling there appeared to be correlation between the concentration of DDT and the species of fish. It also appeared that the size and weight factors of fish tended to cause some problems in analyzing the data. It was determined that the sampling sites in 1965 were too numerous and the sampling design did not include all parts of the state. Therefore, in 1966 the number of sites was reduced to 92 of which 82 were established on major river systems and 10 on freshwater impoundments on Cape Cod. Stations selected for sampling are listed in Table I and shown in Figure I. Ponds were selected on Cape Cod due to the absence of extensive freshwater rivers or streams in that area. After 1965 the samples were standardized to include a minimum of five fish per species per station. At every station where possible, 10 fish of the same species were collected and in some sample stations more than one species of fish were obtained. Since no single species of fish was collected at every sampling station, standardization of species taken to a single species was not possible. However, every effort was made to restrict the number of different species collected for analysis.

A similar sampling schedule and design was followed in 1967. Particular emphasis was made to obtain the same species from each station as had been collected in the previous years.

TABLE I

MASSACHUSETTS PESTICIDE MONITORING STUDY 1965-1967

Pesticide Monitoring Stations in Massachusetts

Station Code No.	Station	Town	Station Code No.	Station	Town
1	Pilgrim Lake	Truro	22	Nemasket River	Middleborough
2	Pamet River	Truro	23	Taunton River	Taunton
3	Herring Pond	Wellfleet	24	Palmer River	Rehoboth
4	Great Pond	Eastham	25	Ten Mile River	North Attleboro
5	Pilgrim Lake	Orleans	26	Mill River	Blackstone
6	Long Pond	Brewster	27	Mumford River	East Douglas
7	Wequaquet Lake	Barnstable	28	Blackstone River	Blackstone
8	Lawrence Pond	Sandwich	29	Quinsigamond River	Grafton
9	Pimlico Pond	Mashpee	30	Charles River	West Medway
10	Johns Pond	Mashpee	31	Charles River	Dover
11	Jenkins Pond	Falmouth	32	Charles River	Boston
12	Agawam River	East Wareham	33	Mystic River	Winchester
13	Weweantic River	Wareham	34	Ipswich River	Reading
14	Mattapoisett River	Mattapoisett	35	Ipswich River	Ipswich
15	Acushnet River	Acushnet	36	Parker River	Newbury
16	West Port River East Branch	Westport	37	Assabet River	Concord
17	Jones River	Kingston	38	Sudbury River	Concord
18	South River	Marshfield	39	Concord River	Lowell
19	North River	Hanover	40	Merrimack River	North Chelmsford
20A	Neponset River West Branch	East Walpole	41	Merrimack River	Lawrence
20B	Neponset River East Branch	Canton	42	Merrimack River	Newburyport
21	Taunton River	Middleborough	43	Shawsheen River	Andover

TAbLE I (continued)

Station Code No.	Station	Town	Station Code No.	Station	Town
44	Nashua River South Branch	Lancaster	69	North River	Colrain
45	Squannacook River	Groton	70	Deerfield River	Charlemont
46	Nashua River North Branch	Fitchburg	71	Cold River	Charlemont
47	French River	Oxford	72	Mill River	Hatfield
48	Quinebaug River	Brimfield	73	Mill River	Northampton
49	Quinebaug River	Southbridge	73	Manhan River	Easthampton
50	Ware River	Barre	75	Fort River	Hadley
51	Ware River	Thorndike	76	Westfield River	Westfield
52	Quaboag River	West Brookfield	77	Little River	Westfield
53	Quaboag River	Palmer	78	Westfield River	Huntington
54	Swift River	Ware	79	Westfield River Middle Branch	Chester
55	Swift River East Branch	Petersham	80	Westfield River West Branch	Chester
56	Swift River Middle Branch	Orange	81	Farmington River West Branch	Sandisfield
57	Swift River West Branch	Shutesbury	82	Hoosic River	Adams
58	Chicopee River	Wilbraham	83	Green River	Williamstown
59	Millers River	Winchendon	84	Housatonic River West Branch	Pittsfield
60	Otter River	Gardner	85	Housatonic River East Branch	Pittsfield
61	Tully River West Branch	Athol	86	Housatonic River Southwest Branch	Pittsfield
62	Millers River	Millers Falls	87	Housatonic River	Stockbridge
63	Connecticut River	Millers Falls	88	Housatonic River	Sheffield
64	Connecticut River	Hadley	89	Williams River	Great Barrington
65	Connecticut River	Longmeadow	90	Green River	Great Barrington
66	Falls River	Bernardston	91	Konkapot River	Monterey
67	Green River	Greenfield	92	Konkapot River	Sheffield
68	Deerfield River	Old Deerfield			

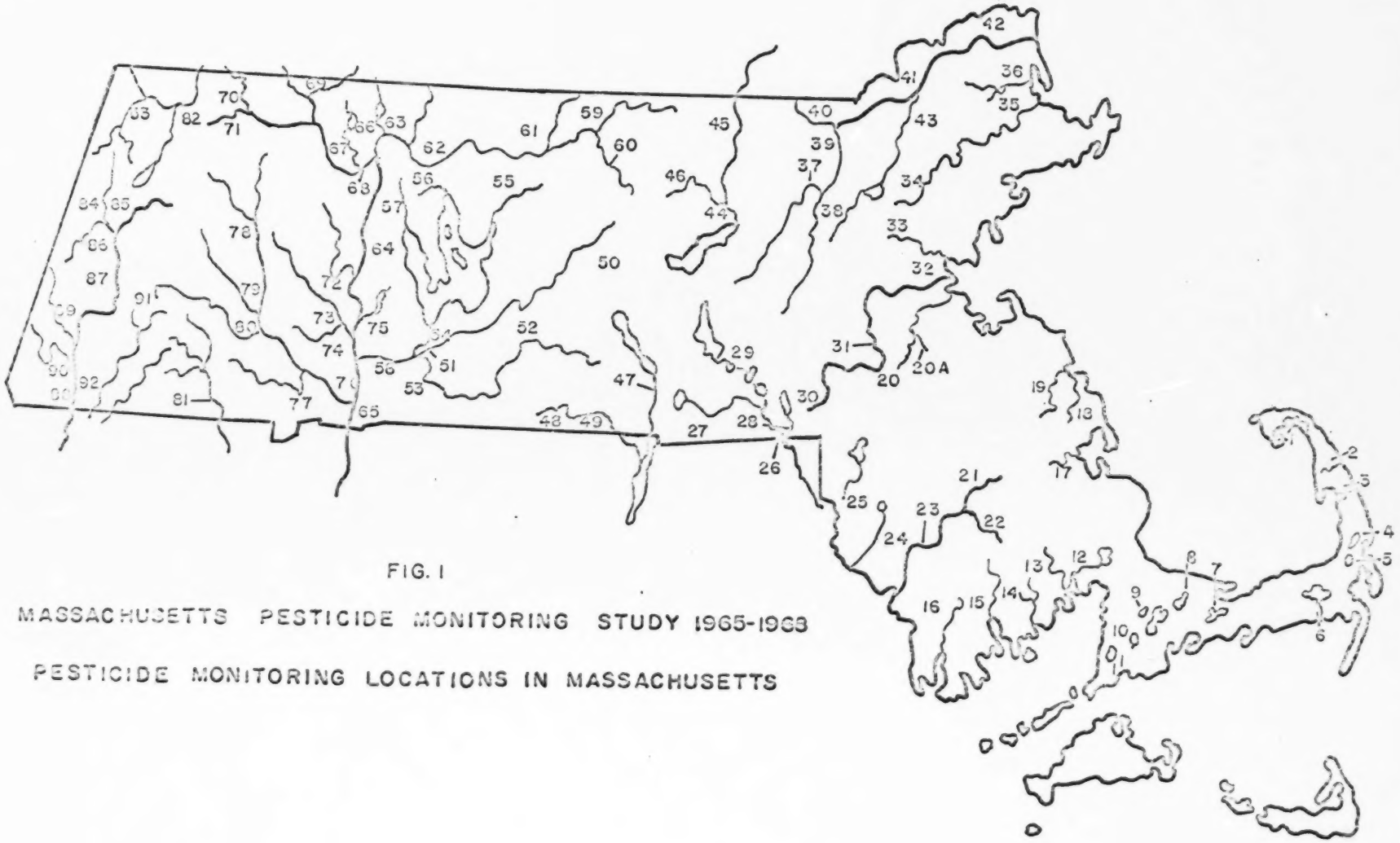


FIG. 1

MASSACHUSETTS PESTICIDE MONITORING STUDY 1965-1968

PESTICIDE MONITORING LOCATIONS IN MASSACHUSETTS

The majority of samples were collected with the use of rotenone. Occasionally an electro-shocker was employed when rotenone proved unsatisfactory. Extensive analysis of the fish exposed to rotenone indicated that the use of rotenone had no significant influence on the analytical method used. Immediately after collection each sample was returned to the laboratory for analysis.

PROCEDURES

Samples received from the field collections were immediately frozen at -25° centrigrade. The elapsed time between collections and subsequent analysis was held to an average of one week.

A minimum of five fish of approximately the same size, weight and species were selected for analysis from each station. The fish were finely minced, placed in Petri dishes, and allowed to dry in a vacuum oven. When the samples were completely dehydrated and the weights recorded, the entire fish was ground in a Waring blender, and a dry gram aliquot removed for the cleanup procedure. The balance of the sample was stored for repeat analysis, if necessary.

A one-step Florisil column method (Langlois, et al) (5) specially adapted for fish tissue was used for the cleanup procedure. The Florisil used was 60/100 mesh activated at 1200°F, reheated prior to use to 140°C for 12 to 14 hours. After cooling to room temperature, 5 ml distilled water were added per 100 grams of Florisil, and the partially inactivated Florisil was then held in an air tight container for 48 hours. The glass columns employed in the procedure were 20mm x 600 mm. with a 550 ml reservoir fixed to the top of each column. The eluant was a mixture of 20% certified Spectranalyzed® methylene chloride in Nanograde® petroleum ether (V/V). Each lot of chemicals was checked for contaminants before use.

The one gram sample was placed in a mortar with 25 grams of Florisil and thoroughly mixed. The chromatographic columns were set up, a glass wool tampon placed just above each stopcock, and 25 grams of conditioned Florisil were added to the columns and purged with 50 ml of a 50/50 mixture of methylene chloride and petroleum ether. The sample mixture (Florisil and tissue) was placed in the column and eluted with 200 ml of the eluent. The eluent was concentrated, quantitatively transferred to a test tube and taken to near dryness under nitrogen. All glassware was rinsed a minimum of three times with 20/80, (methylene chloride/petroleum ether) before use.

The sample was then subjected to the gas chromatograph for identification and quantitation. The pesticide residue was dissolved in 1 ml hexane and a three microliter aliquot was injected into a Wilkins Aerograph Hy-Fi Model 600 instrument with 250 microcurie tritium source electron capture detector. The analytical column used was a 5' x 1/8" coiled Pyrex glass column with a stationary phase of 5% Dow-11 on Chromosorb "W". The oven temperature was maintained at 210°C. The carrier gas, nitrogen, was maintained at a flow rate of 50 ml/min. The column was conditioned for 48 hours prior to use.

In addition to the Dow-11 column, 5% QF-1 on 60/80 chromosorb W was used in an identical oven as a qualitative check. Thin layer chromotagraphy was also employed as a back-up procedure for the identification of DDT and metabolites.

Various amounts of pure standards, diluted to maintain a linear relationship with the detector, were injected four times daily (pre-and post-analysis to check retention time and peak height response. The peak area was used in all calculations.

Percent recovery tests were undertaken periodically and the results are as follows: DDE 63%; DDD (TDE) 75%; O,P DDT 72%; P,P DDT 75%. All data included in the report do not reflect recovery percent.

With each group of ten samples analyzed a "blank" was included in the clean-up procedure to detect possible "contamination".

Inter-laboratory check samples have been analyzed periodically between members of the Residue Analysts Organization of New England in an attempt to standardize qualitative and quantitative procedures.

It was found that 100% recoveries were obtained when 400 ml of eluent were used in the Florisil columns. However, the use of 400 ml per sample was not economically feasible in this project.

RESULTS

As discussed earlier, the data presented in this report are expressed in parts per million (ppm) on a dry weight basis. It is felt that by using dry samples for the analysis a major variable, the loss of weight in conjunction with the time span between collection of samples and their analysis, is eliminated. Both wet and dry weights were recorded before analysis, but dry weights were used for all calculations. To allow comparison of the data to similar work based on wet weight, linear regressions were carried out to convert dry to wet and wet to dry weights (Table 2). These equations allow the simple conversion of one value to the other.

A CDC 3600 computer program (7), was used to calculate the various linear regressions. The program analyzed these regressions applying nine different data transformations. Since no significant increase in the correlation coefficient was obtained by using the various transformations the non-transformed relationships were used in all comparisons.

The b' values shown in Table 2 can alsc be used to convert the ppm of DDT based on wet weight to those based on dry weight. The converse is also true. The conversions can be made by dividing the b' values directly into the ppm. For example: to convert 3.4 ppm of DDT (based on dry weight) for yellow perch to ppm (based on wet weight) 3.4 is divided by 2.6679, yielding 1.274 ppm by the wet weight. To change ppm based on wet weight to ppm based on dry weight, use the appropriate value in the lower part of Table 2. For example: to convert 2.5 ppm of DDT (wet) to ppm of DDT (dry) for yellow perch divide 2.5 by .3327, yielding 7.5 ppm dry weight.

TABLE 2

MASSACHUSETTS PESTICIDE MONITORING STUDY

The Relationship of Dry Weight to Wet Weight for 9 Species of Fish Collected from Massachusetts Waters in 1966

DRY WEIGHT TO WET WEIGHT

Equation: $Y = a + b(X)$

SPECIES	Y	a	b	X	r value	No. of Fish	Length Range (in.)
Yellow perch	Wet Weight	= 11.3765 +	2.6679	(Dry Weight)	.942	125	3.6-8.2
Pumpkinseed	"	= 4.0490 +	3.8032	"	.980	119	3.6-6.3
White sucker	"	= 3.4150 +	3.9648	"	.990	94	4.2-8.9
Fallfish	"	= 2.4262 +	3.8476	"	.986	60	3.1-8.7
Golden shiner	"	= 13.3698 +	2.2274	"	.721*	95	3.6-7.6
Bluegill	"	= 0.9174 +	4.0857	"	.957	40	3.4-6.0
Rock bass	"	= 5.3346 +	3.7608	"	.986	10	4.4-5.0
Creek chub	"	= 2.0017 +	4.1806	"	.943	10	4.4-5.2
Smallmouth bass	"	+ 1.0776 +	4.0838	"	.982	10	4.1-5.6

WET WEIGHT TO DRY WEIGHT

Equation: $X = a + b(Y)$

SPECIES	X	a	b	Y	r value	No. of Fish	Length Range (in.)
Yellow perch	Dry Weight	= -2.3148 +	.3327	(Wet Weight)	.942	125	3.6-8.2
Pumpkinseed	"	= -2.2858 +	.2442	"	.980	119	3.6-6.3
White sucker	"	+ -0.7190 +	.2474	"	.990	94	4.2-8.9
Fallfish	"	= -0.4431 +	.2525	"	.985	60	3.1-8.7
Golden shiner	"	= +0.4173 +	.2334	"	.720*	95	3.6-7.6
Bluegill	"	= +0.5569 +	.2242	"	.957	40	3.5-6.0
Rock bass	"	= -1.1196 +	.2583	"	.986	10	4.4-5.0
Creek chub	"	= +0.0906 +	.2127	"	.943	10	4.4-5.2
Smallmouth bass	"	= -0.0313 +	.2361	"	.982	10	4.1-5.6

* The poor r value for golden shiners is attributed to the fact that five fish had larger than usual wet weights.

MASSACHUSETTS PESTICIDE MONITORING STUDY

1965-1967

Species of fish, and their codes used in this report

SPECIES	CODE	SPECIES	CODE
Yellow perch, *Perca flavescens*	YP	Brown bullhead, *Ictalurus nebulosus*	BB
Pumpkinseed, *Lepomis gibbosus*	P	European carp, *Cyrinus carpio*	C
White sucker, *Catostomus commersoni*	WS	Chain pickerel, *Esox niger*	CP
Golden shiner, *Notemigonus crysoleucas*	GS	Common shiner, *Notropis cornutus*	CS
Fallfish, *Semotilus corporalis*	F	White perch, *Roccus americanus*	
Bluegill, *Lepomis macrochirus*	B	Black crapie, *Pomoxis nigromaculatus*	CRAPIE
Rock bass, *Ambloplites rupestris*	RB	Killifish, *Funduls majalis*	K
Creek chub, *Semotilus atomaculatus*	CC	Satin fin shiner, *Notropis analostanus*	SFS
Smallmouth bass, *Micropterus delomieu*	SMB	Yellowbelly sunfish, *Lepomis auritus*	YBS
Alewife, *Alosa pseudoharengus*	A	Blacknose dace, *Rhinichthys atratulus*	BND
Mummichog, *Fundulus heteroclitus*	M		

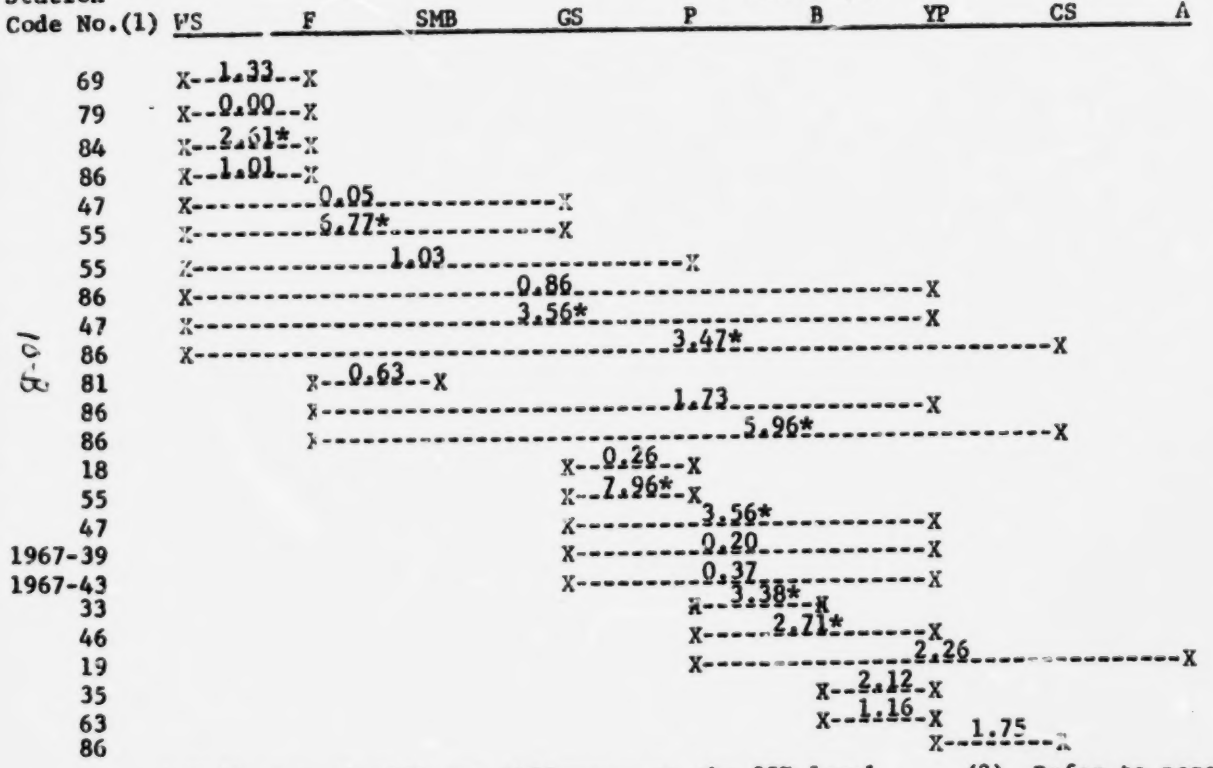
During the evaluation of the 1965 data it appeared that there were inter-specific variations in the concentration of the pesticides. A study was undertaken on samples from 13 different stations in 1966 and 1967 to determine if these variations between species were significant.

The mean concentration of DDT in various species of fish within each station were compared (Snedecor, 1964:87) (8). These tests indicated the differential ability of the fish to concentrate pesticides (Figure 2). However, the results of these comparisons were not clear. Significant differences at the 95% level between the mean concentration of pesticide in two species from a single station were obtained 9 times in 24 comparisons. The inability to obtain a larger sample of two or more species of fish from a station prevented conclusive results. For example at stations 69, 79, 84, and 86 the comparison of the mean concentration found in the same two species of fish (white sucker and fallfish) gave conflicting results. However, at three stations the concentration was similar and was not significantly different at the 5% level. At one station (84) the fallfish sample contained more than 10 parts per million more DDT per fish than did the suckers. The concentration of DDT at this station for fallfish varied from 3.7 ppm to 25.7 ppm whereas the concentration in white suckers varied from 1.6 to 7.7. The lack of agreement between species and extreme variations in some species is obscure.

FIGURE 2

MASSACHUSETTS PESTICIDE MONITORING STUDY
1965-1967

Fifteen sampling stations where more than one species of fish were obtained. The mean of the pesticide concentration of the two species (X) at each station were then compared. The calculated "t" values are given above each comparison (Snedecor). The order in which the species are arranged (left to right) follow their relative concentrations (lowest to highest).



Mean concentration for the five fish of each species (left to right)		(3)
0.96	0.77	←
0.48	0.48	=
4.00	14.80	→
3.54	2.94	←
1.40	1.42	→
0.22	1.35	→
0.22	0.14	←
3.56	4.32	→
1.40	3.56	→
3.54	5.78	→
0.68	0.70	→
2.94	4.32	→
2.94	5.78	→
4.58	4.78	→
1.35	0.14	←
1.42	3.56	→
3.36	3.24	←
3.50	3.34	←
1.94	4.10	→
0.82	1.39	→
1.20	2.30	→
2.54	3.64	→
1.46	1.80	→
4.32	5.78	→

* Indicates significant difference at the 95% level

(1) Refer to Table I, and Figure I

(2) Refer to page 9

(3) Arrows indicate direction of increase for each comparison

An intensive study was planned for the summer of 1967 to determine the varying ability of fish to concentrate pesticides. Coincident with the reclamation of Sandy Pond in Plymouth, Massachusetts, an attempt was made to obtain a sufficient number of fish of different species for analysis. It was felt that a large sample of different species from a land-locked pond might reveal any relationship between size and the ability to concentrate DDT. Unfortunately, only two species of fish (yellow perch and pumpkinseeds) were obtained in this reclamation. A correlation analysis of length to concentration and weight to concentration for these two species (1 to 9.5 inches in length) indicated that there was a poor relationship between these sets of variables. A "t" test (Snedecor, 1964) indicated that there was a significant difference at the 95 percent level in the mean concentration of DDT between these two species. The yellow perch contained on the average 1.9 times more DDT than the pumpkinseeds. It was also noted that the variation among the 93 yellow perch analyzed was higher than that of the 43 pumpkinseeds.

An analysis of variance was applied to certain data obtained in 1965 to determine if there was a significant difference in pesticide concentration between two sizes of yellow perch taken from the same body of water. The analysis was done on five fish per size group. The resulting data indicated no significant difference between size groups. The variation that occurred was attributed to small sample size. The data obtained from the 93 yellow perch from Sandy Pond were also subjected to analysis of variance methods to determine if there was a significant difference in DDT concentration between various size groups. The size classes were divided into two inch intervals, (ranging from 3 to 10 inches) the results indicated that there was no significant difference at the 95% level between the various size classes.

CONCLUSION

The overall results obtained from the 93 sampling locations over the state of Massachusetts are presented in Table 3. There was not an apparent definite relationship between the mean concentration of DDT in a total sample and the variability of the pesticide in the individual members of the sample. However, for yellow perch, the samples showing the highest variability also showed the highest mean concentration. The distribution of the variance within samples followed a negative binomial distribution. The importance of this is unknown and needs further investigation.

The analysis of the data indicated sources of variation which could not be explained by considering the species of fish, their length or weight. Frequently concentrations of DDT in individual species taken from the same station fluctuated without explanation.

These variations may in part be caused by migrating populations or varied feeding habits of the individual fish. They also might be explained through further study investigating lipid content, stomach contents and food habits correlated with sex of the individual fish.

The present study indicated that some species of fish do exhibit marked differences in their ability to concentrate pesticides. Because of this factor it is impossible to compare the pesticide concentrations between locations when different species of fish were examined. In general, it is felt that the results of this study indicate that using a single fish species as an indicator allows one to determine trends in pesticide levels within a station over a period of years, but does not allow comparison of results between watersheds.

TABLE 3

MASSACHUSETTS PESTICIDE MONITORING STUDY 1965-1967

Mean concentrations of DDT, DDD and DDE found in 1,310 fish collected from 93 different stations throughout Massachusetts over a three-year period. Results are expressed in parts per million.

STATION*	DATE COLLECTED	NO. OF SAMPLES	SPECIES**	DDT	DDD	DDE.	TOTAL	STANDARD DEVIATION
1	65	0	--	----	----	----	----	-----
	6/28/66	5	WP	0.18	1.30	0.86	2.34	4.012
	8/21/67	5	WP	0.18	0.40	0.34	0.92	0.295
2	65	0	--	----	----	----	----	-----
	6/28/66	5	P	0.18	3.70	2.16	6.04	1.443
	8/21/67	10	P	0.54	1.51	1.83	3.88	1.135
3	65	0	--	----	----	----	----	-----
	6/28/66	5	GS	0.00	0.28	0.39	0.67	0.729
	8/21/67	5	GS	0.12	0.52	0.84	1.48	0.205
4	65	0	--	----	----	----	----	-----
	6/29/66	5	P	0.02	0.09	0.16	0.27	0.327
	8/22/67	5	P	0.28	0.24	0.42	0.94	0.195
5	65	0	--	----	----	----	----	-----
	6/29/66	5	YP	0.52	0.76	0.94	2.22	0.638
	8/22/67	5	P	0.54	0.72	1.14	2.40	0.583
6	65	0	--	----	----	----	----	-----
	6/27/66	5	YP	0.70	1.02	1.00	2.72	0.455
	8/22/67	5	YP	0.46	1.00	1.42	2.88	1.746
7	65	0	--	----	----	----	----	-----
	6/27/66	5	GS	0.00	0.18	0.50	0.68	0.268
	8/23/67	5	YP	0.52	0.76	1.00	2.28	1.117
8	6/ 5/65	1	YP	0.20		0.50	0.70	0.000
	6/27/66	5	YP	0.26	0.72	1.60	2.58	0.559
	8/23/67	5	YP	0.34	0.56	1.82	2.72	0.383
9	65	0	--	----	----	----	----	-----
	6/28/66	5	YP	0.15	0.78	0.78	1.71	0.513
	8/23/67	5	P	0.28	0.54	1.34	2.16	0.488

* Refer to Table I and Figure I
** Refer to page 9 for species code

TABLE 3 (continued)

10	65	0	--	----	----	----	----	-----
	6/30/66	5	YP	0.18	0.28	0.48	0.94	0.230
	8/24/67	5	YP	0.22	0.32	0.48	1.02	0.205
11	65	0	--	----	----	----	----	-----
	6/28/66	5	P	0.02	0.3[illegible]	0.76	1.16	0.385
	8/24/67	5	P	0.36	0.[illegible]4	0.74	1.64	0.513
12	65	0	--	----	----	----	----	-----
	9/13/65	5	B	0.30	0.48	1.12	1.90	0.141
	6/ 2/67	5	P	0.28	0.58	0.64	1.50	0.485
13	8/24/65	3	SFS	0.40		0.53	0.93	0.306
	6/23/66	5	YP	0.42	2.32	2.58	5.32	0.887
	8/ 5/67	5	P	0.26	0.82	0.44	1.52	0.652
14	8/25/65	5	P	9.14		1.96	11.10	4.460
	6/24/66	5	P	0.28	2.32	1.04	3.64	1.258
	6/ 9/67	10	P	2.16	1.23	1.25	4.64	1.341
15	8/25/65	3	B	2.36		0.87	3.23	0.893
	6/24/66	5	B	0.32	1.18	0.94	2.44	0.385
	6/21/67	5	B	1.00	2.32	1.20	4.52	1.535
16	8/27/65	3	YP	2.21		0.25	2.46	0.917
		1	P	6.06		0.42	6.48	0.000
	7/ 6/66	5	P	0.50	0.54	0.62	1.66	0.261
	6/ 6/67	5	P	0.28	0.40	0.28	0.96	0.230
17	8/23/65	2	CS	0.77		0.50	1.27	0.842
		1	B	1.62		1.17	2.79	0.000
	6/20/66	5	P	0.80	6.74	3.54	11.08	1.918
	6/20/67	10	P	0.36	0.72	0.76	1.85	0.495
18	8/19/65	1	B	7.80		4.41	12.21	0.000
	6/23/66	10	P	0.36	2.38	2.43	5.17	1.350
		10	GS	0.04	1.50	3.14	4.68	0.976
	7/14/67	5	GS	0.19	1.70	2.18	4.07	1.050
19	8/17/65	5	P	0.99		0.28	1.28	0.298
	6/22/66	5	A	0.34	0.88	1.08	2.30	0.843
	9/14/66	5	P	0.30	0.44	0.46	1.20	0.682
	7/26/67	5	P	0.64	1.16	0.82	2.62	0.962
20A	8/17/65	5	B	1.71		1.79	3.51	0.966
20	8/17/65	4	B	1.29		0.37	1.66	0.483

TABLE 3 (continued)

21	65	0	--	----	----	----	----	-----
	6/17/66	5	YP	0.30	1.12	0.98	2.40	0.412
	8/ 4/67	5	CS	0.28	0.80	0.90	1.98	0.536
22	9/ 1/65	5	CS	1.06		0.71	1.77	0.447
	6/17/66	5	YP	0.40	0.90	0.62	1.92	0.585
	8/ 4/67	5	CS	0.30	1.02	0.92	2.24	0.635
23	65	0	--	----	----	----	----	-----
	9/13/66	5	M	0.98	2.00	3.20	6.18	0.476
	9/13/67	5	M	2.76	3.64	4.10	10.50	1.225
24	65	0	--	----	----	----	----	-----
	6/21/66	5	P	0.44	0.50	0.52	1.46	0.527
	6/21/67	5	WP	1.72	2.26	1.38	5.36	1.029
25	9/17/65	1	CP	1.00		1.00	2.00	0.000
	6/21/66	5	BB	0.32	1.20	0.90	2.42	0.709
	6/22/67	5	P	0.46	0.62	0.72	1.80	0.735
26	6/ 7/65	5	CS	1.92		0.70	2.62	0.899
	6/10/66	5	P	0.38	0.56	0.42	1.36	0.391
	8/ 3/67	5	B	0.00	1.34	0.62	1.96	0.808
27	65	0	--	----	----	----	----	-----
	6/17/66	5	GS	0.32	0.24	0.36	0.92	0.295
	6/23/67	5	P	0.50	0.48	1.08	2.06	1.284
28	65	0	--	----	----	----	----	-----
	9/ 7/66	5	C	0.26	0.24	4.78	5.28	0.598
	8/ 3/67	5	C	0.98	1.92	1.60	4.45	0.513
29	7/ 2/65	2	B	0.62		0.26	0.88	0.644
	6/14/66	5	B	0.18	0.40	0.34	0.92	0.403
	6/28/67	5	P	1.20	1.18	0.82	3.20	1.283
30	65	0	--	----	----	----	----	-----
	6/15/66	5	GS	0.26	0.86	1.64	2.76	0.780
	6/26/67	10	P	1.47	1.92	1.31	4.70	1.697
31	7/29/65	1	YP	3.20		1.40	4.60	0.000
	6/29/66	4	P	0.15	0.57	0.68	1.40	0.245
	7/ 6/67	5	B	0.26	0.56	0.62	1.44	0.428

TABLE 3 (continued)

32	65	0	--	----	----	----	----	-----
	9/19/66	5	M	0.70	1.70	1.16	3.56	0.921
	8/ 9/67	10	M	1.39	2.29	1.28	4.96	1.139
33	65	0	--	----	----	----	----	-----
	7/14/66	10	B	0.97	1.22	1.35	3.54	0.965
		10	P	0.34	0.48	1.01	1.83	1.260
	6/27/67	10	P	0.90	0.89	1.07	2.86	0.886
34	9/ 9/65	5	P	3.85		0.69	4.54	1.540
	7/ 7/66	5	GS	0.14	0.68	2.42	3.24	0.841
	10/ 2/67	5	B	1.34	0.90	1.14	3.38	0.396
35	9/ 9/65	3	B	0.84		0.30	1.14	0.182
	7/ 7/66	10	YP	0.42	1.44	1.46	3.32	0.721
		10	B	0.29	0.71	0.97	1.97	0.878
	6/29/67	5	B	1.00	0.74	0.86	2.60	0.579
36	9/14/65	3	P	0.89		0.78	1.67	0.368
	7/11/66	5	CP	0.02	0.30	0.84	1.16	0.134
	7/ 5/67	5	P	0.20	1.00	0.62	1.82	0.110
37	7/22/65	5	YP	5.74		1.82	7.56	4.165
	6/28/66	5	YP	1.96	5.68	4.00	11.64	2.528
	7/ 7/67	5	CS	0.46	1.00	1.08	2.54	0.456
38	65	0	--	----	----	----	----	-----
	7/ 5/66	5	YP	3.16	3.76	3.34	10.26	0.777
	7/ 7/67	5	WP	2.18	3.50	2.16	7.84	1.496
39	7/26/65	1	YP	5.37		1.89	7.26	0.000
		3	P	2.39		1.02	3.41	0.708
	7/13/66	5	GS	1.04	2.06	4.22	7.32	2.537
	7/10/67	5	GS	1.10	1.14	1.12	3.36	0.789
		5	YP	1.04	1.30	0.90	3.24	1.130
40	65	0	--	----	----	----	----	-----
	10/11/66	5	WS	1.66	4.74	3.12	9.52	1.886
	7/10/67	5	GS	0.94	2.66	1.68	5.28	1.203
41	7/26/65	4	CS	3.31		1.90	5.20	1.408
	7/13/66	5	P	0.38	1.18	1.16	2.72	2.155
	8/14/67	10	P	0.99	2.05	1.51	4.55	0.649
42	7/27/65	1	K	5.88		2.35	8.23	0.000
	66	0	--	----	----	----	----	-----
	8/14/67	5	P	1.14	1.70	1.06	3.90	2.043

TABLE 3 (continued)

43	9/13/65	1	P	0.86		3.10	3.96	0.000
		4	WS	1.40		2.52	3.92	0.607
	7/13/66	5	GS	0.20	1.14	2.22	3.56	1.324
	7/10/67	5	GS	0.76	1.44	1.30	3.50	0.613
		5	YP	1.34	1.20	0.80	3.34	0.770
44	65	0	--	----	----	----	----	-----
	7/15/66	5	P	0.58	0.60	1.12	2.30	0.897
	7/10/67	10	P	0.64	0.61	0.61	1.86	0.375
45	8/ 4/65	1	P	5.34		1.98	7.32	0.000
	7/21/66	5	GS	0.00	0.28	1.04	1.32	0.239
	7/11/67	5	YP	0.48	0.50	1.08	2.06	0.404
46	65	0	--	----	----	----	----	-----
	7/21/66	5	P	0.12	0.28	0.42	0.82	0.259
		5	YP	0.19	0.56	0.64	1.39	0.397
	7/11/67	10	YP	0.40	0.65	0.57	1.62	0.402
47	8/10/65	2	B	0.60		0.75	1.35	0.071
	6/ 7/66	10	YP	0.33	0.85	1.43	2.61	1.421
		10	GS	0.13	0.39	1.26	1.78	0.719
		10	WS	0.40	0.60	0.54	1.54	0.263
	7/12/67	5	GS	0.44	0.66	1.16	2.26	0.398
48	8/10/65	3	YP	0.43		0.48	0.91	1.287
	7/18/66	5	YP	0.32	0.34	0.39	1.05	0.553
	7/12/67	5	YP	0.48	0.58	0.50	1.56	0.152
49	8/10/65	1	YP	0.19		0.24	0.43	0.000
	7/12/66	5	GS	0.28	0.64	1.98	2.90	0.292
	7/12/67	5	YP	0.88	0.90	0.96	2.74	0.416
50	9/ 9/65	5	BND	0.14		0.48	0.62	0.235
	7/22/66	5	YP	0.18	0.24	0.40	0.82	0.192
	7/14/67	5	YP	0.50	0.40	0.76	1.66	0.089
51	65	0	--	----	----	----	----	-----
	7/26/66	5	GS	0.00	0.62	2.20	2.82	1.406
	7/13/67	10	GS	0.55	1.55	1.99	4.09	0.751
52	65	0	--	----	----	----	----	-----
	7/18/66	5	YP	0.18	0.50	0.84	1.52	0.701
	7/14/67	5	YP	0.16	0.32	0.34	0.82	0.622

TABLE 3 (continued)

53	65	0	--	----	----	----	----	-----
	7/19/66	5	GS	0.18	0.42	1.32	1.92	0.707
	7/14/67	5	YBS	0.44	0.46	0.46	1.36	0.261
54	65	0	--	----	----	----	----	-----
	7/25/66	5	GS	0.00	0.36	1.34	1.70	0.283
	7/14/67	5	YP	0.30	0.40	0.50	1.20	0.412
55	10/ 5/65	5	FF	0.30		0.32	0.62	0.726
	7/22/66	10	WS	0.00	0.03	0.16	0.19	0.149
		10	GS	0.03	0.15	1.05	1.23	0.285
		10	P	0.00	0.00	0.17	0.17	0.048
	7/17/67	5	WS	0.08	0.08	0.16	0.32	0.179
56	10/ 6/65	5	YP	0.53		0.49	1.02	0.610
	7/28/66	5	YP	0.12	0.28	0.42	0.82	0.604
	7/18/67	5	YP	0.18	0.26	0.30	0.74	0.391
57	65	0	--	----	----	----	----	-----
	9/ 4/66	5	WS	0.24	0.24	0.40	0.88	0.148
	7/17/67	5	RB	0.42	0.30	0.70	1.42	0.327
58	9/17/65	1	B	0.80		0.60	1.40	0.000
		1	P	0.20		0.20	0.40	0.000
	7/29/66	5	P	0.33	0.37	0.40	1.10	0.592
	8/ 1/67	5	YP	0.66	1.22	1.92	3.80	1.010
59	8/ 5/65	3	YP	0.54		0.41	0.95	0.271
		1	FF	0.37		0.50	0.87	0.000
	7/27/66	5	YP	0.26	0.42	0.56	1.24	0.581
	7/19/67	10	YP	0.51	0.54	0.36	1.41	0.438
60	65	0	--	----	----	----	----	-----
	9/ 9/66	5	WS	0.32	0.80	0.44	1.56	0.581
	1/20/67	5	GS	1.02	1.56	1.08	3.66	0.626
61	9/21/65	5	YP	0.14		0.26	0.40	0.149
	7/27/66	5	YP	0.42	1.26	1.64	3.32	1.365
	7/18/67	10	YP	0.67	0.83	0.80	2.30	0.796
62	65	0	--	----	----	----	----	-----
	8/ 1/66	5	P	0.36	0.80	0.68	1.84	0.709
	7/24/67	5	YP	3.16	4.28	3.62	11.06	4.624

TABLE 3 (continued)

63	9/ 9/65	1	B	1.32		0.72	2.04	0.000
		1	YP	0.95		0.39	1.34	0.000
	9/ 9/66	5	B	0.34	0.58	0.54	1.46	0.361
		5	YP	0.50	0.64	0.66	1.80	0.570
	7/21/67	5	YP	1.20	1.74	1.30	4.24	0.631
64	65	0	--	----	----	----	----	-----
	10/ 5/66	5	FF	0.36	1.12	2.92	4.40	0.846
	7/31/67	5	FF	0.70	2.96	3.56	7.22	0.753
65	10/ 1/65	2	B	0.30		0.45	0.75	0.495
	7/29/66	5	P	0.72	0.92	1.10	2.74	0.089
	8/10/67	5	P	1.46	1.86	1.16	4.48	1.361
66	65	0	--	----	----	----	----	-----
	7/26/66	5	FF	0.00	0.12	1.24	1.36	0.219
	7/26/67	5	FF	0.40	0.78	1.48	2.66	0.385
67	8/14/65	1	WS	1.60		1.30	2.90	0.000
	8/ 1/66	5	FF	0.52	1.62	2.84	4.98	0.760
	7/28/67	5	FF	0.74	1.34	2.52	4.60	0.561
68	10/28/65	2	WS	0.10		0.80	0.90	0.000
		3	FF	0.40		1.40	1.80	0.889
	7/22/66	5	RB	0.76	1.02	3.34	5.12	0.890
	8/ 7/67	5	P	0.78	0.52	1.34	2.64	0.888
69	65	0	--	----	----	----	----	-----
	8/ 2/66	9	WS	0.22	0.20	0.18	0.83	0.180
		10	FF	0.08	0.13	0.52	0.82	0.123
	7/28/67	10	FF	0.00	0.30	0.60	0.90	0.000
70	65	0	--	----	----	----	----	-----
	66	0	--	----	----	----	----	-----
	67	0	--	----	----	----	----	-----
71	8/14/65	5	CC	0.02		0.46	0.48	0.110
	8/ 2/66	5	CC	0.04	0.18	0.68	0.90	0.412
	67	0	--	----	----	----	----	-----
72	8/ 8/65	2	YP	1.86		0.50	2.36	0.955
	8/ 4/66	5	YP	0.44	0.50	0.58	1.52	0.163
	8/ 8/67	5	YP	1.34	1.30	1.24	3.88	2.365

TABLE 3 (continued)

73	8/21/65	2	YP	13.23		2.78	16.00	6.831
	8/ 4/66	5	P	2.58	3.50	2.12	8.20	1.914
	8/ 9/67	5	YP	2.86	3.48	2.16	8.50	3.519
74	8/11/65	4	WS	0.45		0.31	0.76	0.202
	8/ 8/66	5	YP	0.60	1.20	1.28	3.08	0.228
	8/ 9/67	5	YP	1.84	3.12	2.42	7.38	2.973
75	8/ 7/65	1	WS	0.24		0.16	0.40	0.000
		1	B	0.48		0.18	0.66	0.000
	8/ 4/66	5	RB	0.46	0.58	0.76	1.80	0.480
	8/ 8/67	5	RB	0.64	0.90	0.98	2.52	0.694
76	9/22/65	4	CS	0.09		0.98	1.06	0.512
	7/29/66	5	GS	0.46	1.62	2.08	4.16	0.643
	8/10/67	5	FF	0.90	3.20	3.16	7.26	0.786
77	65	0	--	----	----	----	----	-----
	8/ 5/66	5	WS	1.38	2.74	2.88	7.00	3.888
	8/13/67	5	WS	3.90	11.80	13.18	28.88	17.583
78	8/12/65	2	CS	1.35		1.80	3.15	3.182
	8/ 5/66	5	SMB	0.20	0.38	0.82	1.40	0.857
	8/14/67	5	SMB	0.60	0.50	0.60	1.70	0.846
79	8/12/65	2	CS	0.16		0.76	0.92	0.233
	8/ 9/66	10	WS	0.09	0.09	0.20	0.38	0.193
		10	FF	0.07	0.07	0.37	0.51	0.179
	8/14/67	10	BND	0.00	0.40	0.50	0.90	0.000
80	65	0	--	----	----	----	----	-----
	8/ 9/66	5	WS	0.72	0.62	0.60	1.94	0.089
	8/13/67	5	WS	0.38	0.60	0.72	1.70	0.300
81	8/20/65	1	FF	0.00		0.30	0.30	0.000
	8/11/66	5	SMB	0.20	0.20	0.30	0.70	0.000
		5	FF	0.00	0.10	0.58	0.68	0.148
	8/15/67	9	FF	0.47	0.39	0.71	1.57	0.123
82	9/29/65	1	FF	2.80		2.00	4.80	0.000
		1	WS	1.21		1.30	2.51	0.000
	8/ 3/66	5	CC	0.34	0.64	2.42	3.40	0.742
	67	0	--	----	----	----	----	-----
83	65	0	--	----	----	----	----	-----
	8/ 3/66	5	FF	0.50	0.30	1.28	2.08	0.726
	8/30/67	5	WS	0.70	0.72	0.52	1.94	0.391

TABLE 3 (continued)

84	10/24/65	5	WS	1.55		0.38	1.93	1.207
	8/10/66	10	FF	1.13	4.31	7.44	12.88	7.130
		10	WS	1.57	2.09	1.29	4.95	2.088
	8/29/67	10	WS	0.83	1.41	0.73	2.97	0.747
85	10/27/65	4	WS	1.35		1.97	3.32	2.350
	66	0	--	----	----	----	----	-----
	67	0	--	----	----	----	----	-----
86	10/26/65	2	FF	1.55		1.65	3.20	2.977
		1	WS	0.92		0.45	1.37	0.000
	8/10/66	5	FF	0.44	0.92	1.58	2.94	0.639
	5	5	YP	1.32	1.76	1.24	4.32	1.660
		5	CS	1.20	2.00	2.58	5.78	0.853
		5	WS	1.10	1.58	0.86	3.54	1.163
	8/29/67	10	WS	2.22	2.32	1.05	5.59	1.066
87	10/26/65	5	FF	1.46		0.73	2.20	0.913
	66	0	--	----	----	----	----	-----
	67	0	--	----	----	----	----	-----
88	9/30/65	5	CS	1.64		0.62	2.26	0.603
	10/13/66	5	P	1.02	2.02	0.96	4.00	0.367
	8/17/67	5	CRAPIE	8.44	10.68	1.94	21.06	3.907
89	10/19/65	2	FF	0.15		0.17	0.32	0.255
		1	CS	1.90		2.60	4.50	0.000
		1	WS	3.70		4.60	8.30	0.000
	9/20/66	5	WS	1.90	2.44	0.98	5.32	2.979
	8/18/67	10	WS	9.33	9.90	2.47	20.69	6.678
90	65	0	--	----	----	----	----	-----
	8/11/66	5	WS	1.76	1.92	1.50	5.18	2.139
	8/16/67	5	WS	11.16	12.50	2.88	26.54	13.211
91	65	0	--	----	----	----	----	-----
	8/11/66	5	WS	1.32	0.74	0.98	3.04	1.341
	8/16/67	10	WS	0.35	0.33	0.33	1.01	0.228
92	65	0	--	----	----	----	----	-----
	66	0	--	----	----	----	----	-----
	8/17/67	5	RB	8.26	10.76	4.34	23.36	7.555

The chemical names of compounds mentioned in this paper are:

DDT	1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane
DDE	1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene
DDD (TDE)	1,1-dichloro-2,2-bis(p-chlorophenyl)ethane

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